THE EXTERNAL MORPHOLOGY OF HYDROPHILUS OBTUSATUS SAY (COLEOPTERA: HYDROPHILIDAE)*

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I. INTRODUCTION

Hydrophilus obtusatus Say was selected for this study on account of its fairly large size, and because of its relative abundance and wide distribution which probably make it the most readily available species of the larger hydrophilids in this country. Moreover, there are several closely allied species belonging to the same genus, *Hydrophilus,* which could be substituted for *H. obtusatus* in case it were desirable to use such a beetle for class work. Although not as large as *Hydrous triangularis* Say or the rarer *Hydrous ovatus* G. & H., and so perhaps less desirable for study, the members of *Hydrophilus* seem to be more equally distributed over the world and have not been studied as extensively. The immature stages have been described by Bowditch, 1884; Wickham, 1895b; Richmond, 1920; and Wilson, 1923. A complete morphological study of a water beetle has never been made in the United States, and it is hoped that such a contribution may be of some value to the student as well as to the trained morphologist. It would be worth while if more extensive studies such as that of Korschelt, 1923, on *Dytiscus marginalis* L., were conducted in this country.

Several workers have figured *Hydrophilus* as one of a series illustrating the comparative anatomy of Coleoptera and other groups but no complete study of the external anatomy of *Hydrophilus* has been made. Forbes, 1922, and Stickney, 1923, have used both *Hydrous triangularis* and *Hydrophilus obtusatus* in their respective studies of the wings and head capsules of Coleoptera. *Hydrous triangularis* was used and figured by Newell, 1918, in her study of the male and female genitalia of Coleoptera; by Crampton, 1926, for his consideration of the

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neck and prothoracic sclerites of insects; and Tanner, 1927, in his paper on the female genitalia of Coleoptera.

Most European writers who have described the Hydrophilidæ have written concerning *Hydrous piceus* L., the largest and possibly the most common species of Europe, but the genus *Hydrophilus* has been somewhat neglected, except by d'Orchymont, 1911. Sharp and Muir, 1912, described the genital tubes of *Hydrous piceus* L., *Laccobius ytenensis* Sharp, *Berosus signaticollis* Sharp, *Berosus luridus* L., *Helophorus aquaticus* L., and *Dactylosternum subdepressum* Lap., in their paper on the comparative anatomy of the male genital tube in Coleoptera. In 1894, Escherich discussed the male genital system of Coleoptera and included *Hydrous piceus* L., Berlese, 1909, used drawings of *Hydrous piceus* L., and *Hydrobius fuscipes* L., in connection with a number of his morphological explanations. The most valuable piece of research on any one species was contributed by Balfour-Browne, 1911, as a result of his studies on *Hydrobius fuscipes* L., and many valuable ideas on the morphology of a hydrophilid were obtained from a study of his work. Brocher, 1912, carefully described the respiratory system of *Hydrous piceus* in great detail.

The specimens used for this present study were collected in swampy meadows adjacent to the campus pond of the Massachusetts Agricultural College at Amherst, Massachusetts. They were preserved in eighty per cent. ethyl alcohol until needed for study. In order to remove the soft tissues from the sclerotized portions of the beetle some of them were boiled in a ten per cent. solution of caustic potash. For examining the structures a Spencer binocular was used together with a Spencer high power Mazda microscope lamp (400 watts, 100 volts) for illumination. All of the measurements for the drawings were made by means of a cross-section, ocular micrometer, and the original drawings were sketched on cross-section paper, the squares of which were calibrated.

The drawings were then traced on bristol board and inked in, after being carefully checked over with other specimens besides the one drawn originally. As an explanation of the drawings it should be noted that the membranous areas have been closely stippled whereas the lightly sclerotized regions have been only sparsely stippled. The interrupted or broken lines represent indefinite margins, indistinct areas, or underlying structures and the dotted lines have been used to indicate indistinct sutures, elevations, or depressions.

The investigations included in this paper were conducted entirely under the direction of Dr. G. C. Crampton, and I desire to thank him sincerely for his helpful advice and most considerate criticism. It was at the suggestion of Dr. H. T. Fernald that a morphological paper was included in my studies, and both he and Dr. C. P. Alexander have materially aided in my researches. For financial assistance I am greatly indebted to Mr. Edward M. Thompson of Brockton, Massachusetts, and to Mr. Otto Haas of the Rohm and Haas Company of Philadelphia, Pa.

II. History and General Description

The subfamily Hydrophilinæ, of which *Hydrophilus obtusatus* Say is a member, also includes the genera *Hydrous* Dahl, *Neohydrophilus* d'Orchymont, and *Tropisternus* Solier. *Dibolocelus* Bedel is now placed in the genus *Hydrous* as a subgenus. This subfamily is primarily distinguished from the other subfamilies of the Hydrophilidæ by the presence of an acute metasternal spine and its compressed meso- and metathoracic tarsi, which form oar-like appendages for swimming. The general color is usually reddish brown to pitchy black although some of its species occasionally possess yellow margins. The size varies from 9 mm. to 35 mm. in length.

The genus *Hydrophilus* was erected by De Geer in 1774, and *H. caraboides* L., was selected by Leach in 1815 as the type of the genus. The short, metasternal spine, never projecting as far as the caudal margin of the first ventral segment, and the acutely carinate prosternum, not grooved for the reception of the mesosternal carina, isolate this genus from the other members of the subfamily Hydrophilinæ.

The first specimen of this species to be recognized was collected by its author, Thomas Say, on one of his expeditions to the Rocky Mountains, and was described by him in 1823 as follows:

"Body oblong-oval, convex, black; head, a lunate indented line of confluent punctures befores the eyes on each side; orbits punctured; palpi and base of the antennæ, dark rufous; thorax with a very much abbreviated line of impressed punctures on each side before the middle, and a few lateral punctures; elytra very obtusely rounded behind; four series of punctures furnishing minute hairs, the outer one double; beneath sericeous, with minute yellowish hairs; pectus, prominence not bifid; sternum narrow and not canaliculate before, slightly emarginate near the anterior tip; posterior moiety a little flattened, with an impressed line; posterior tip rounded and hardly extending beyond the base of the postpectus; feet dark piceous. Length from 3/5 to 13/20 of an inch."

It is unfortunate that the original type has been destroyed and it would be quite advisable to select another individual or group of individuals to stand in its place.

Hydrocharis obtusatus has been included under *Hydrochara* Berth., 1827; *Hydrous* Brullé, 1835; *Hydrocharis* Hope, 1838; *Hydrœchus* Steph., 1838; and *Hydrochares* Solsky, 1876; but now seems to be properly placed in the genus *Hydrophilus.* It is very close to *H. caraboides* L. which is readily distinguished by the caudal, spine-like projection of its prothoracic keel. Zimmerman (see Le Conte, 1869) described a specimen, closely related to *Hydrophilus obtusatus* Say as *Hydrophilus grandis,* but Horn, 1876, considered it to be only a female of *H. obtusatus.* Only the elytra of Zimmerman's specimen now remain, so that it will be difficult to prove whether or not Horn's assumption was correct.

Knisch, 1924, lists *H. obtusatus* as a North American species and it does seem to be fairly well distributed over Canada and the United States. Literature and records at hand report its occurrence in Manitoba and Ontario, Canada; all of the New England states; New York, New Jersey, Pennsylvania, South Carolina, Florida, Michigan, Indiana, Illinois, Kansas, Texas, New Mexico, and Washington. The other species of the genus *Hydrophilus* occurring in the United States are *H. castus* Say, *H. lineatus* Lec., and *H. rickseckeri* (Horn). The two latter species seem to be confined to the most western states while the first is southern in its distribution. *H. castus* Say has been placed in the genus *Neohydrophilus* by d'Orchymont principally on account of its emarginate fronto-clypeus while the other species are left in the genus *Hydrophilus* in the strict sense.

III. The Head and its Appendages

Head Capsule (Figs. 1 and 2):—The head capsule of *H. obtusatus* Say is practically circular in outline, when viewed from above, and is somewhat slightly depressed although it is well rounded out. It is inserted in the prothorax as far as the caudal margin of the eyes so that the occiput and the caudal portion of the vertex is concealed. The *compound eyes* (e), which protrude from the sides of the head, are large and appear cordate from above, but being emarginate caudad are reniform when viewed from the side.

The *epicranial suture* (es) is distinct and almost attains the caudal margin of the vertex. Cephalad it extends along the median line to a point between the eyes, where it divides into a right and a left arm called the *antenno-frontal sutures* (afs) but also known as frontal sutures. Each of these sutures curves outwardly, dips slightly caudad at a point near the eye, then passes in front of the eye to the lateral margin of the head, where it extends ventro-mesad and finally terminates near the dorsal condyle (precoila).

The two portions of the *vertex* (v), separated in part by the epicranial suture, are termed the *parietals* (pa) and each of these is set off at the side of the head from the postgena and gena by a poorly defined ridge. This ridge is continuous with the rounded posterior margin of the vertex and extends to the caudal region of the eye. A small shallow depression is present mesad near the hind margin of the vertex.

The *occiput* (oc) is not clearly demarked, and merges dorsad with the vertex. Two short, vertical grooves occur in the occipital region just laterad of the *occipital foramen* (of).

Each *postgena* (pg) has a shiny, glabrous, quadrangular area at the side of the head near its posterior margin. The cephalic margin of each *gena* (ge) follows the thumbprint-shaped caudal emargination of the eye and is continued along the caudo-ventral margin of the eye. It is a question as to just what constitutes the postgena. According to Stickney, 1923, each postgena is a narrow area, bearing the acetabulum (postcoila) for the reception of the condyle of the mandible and is situated just laterad of the base of the submentum. I am inclined to consider, however, that the postgena is fused with the gena and that it really extends from the hypostomal region to the caudal region of the head, where it takes part in the formation of the occiput.

Immediately in front of each eye there is a small, triangular area which in this paper is termed the *parocular sclerite* (pl). It is called the "second sternite" or "antennal sclerite" by d'Orchymont, 1913, but, since I can not agree with his attempt to name the somites of the head, such terms do not seem acceptable until more definite proof of their origin can be presented. This parocular sclerite extends almost to the caudal margin of the eye as a narrow rim along the mesal side of the eye, and also laterad in front of the eye until it unites with a narrow, antennal sclerite which surrounds the base of the antenna. Such parocular areas are present in other species of the genus *Hydrophilus* as well as in the genera *Hydrous, Tropisternus, et al.,* but are most prominent in *Hydrophilus.* The short but well-defined suture demarking each parocular sclerite is named the *parocular suture* (pls). The setiferous punctures, which are present on these sclerites, together with those just caudad but separated off by the parocular sutures, are called the *interocular series* (is).

Each *frontal pit* is located near the end of the antenno-frontal suture just laterad of the dorsal condyle (precoila). The reason for such a location of the frontal pits is doubtless due to a deflection of the lateral margins of the head. The anterior articulations of the mandibles, as well as the frontal pits, have thus been forced to assume a ventral position rather than the more primitive, dorsal position as represented by Stickney, 1913, in his hypothetical type or even by the genus *Hydraena,* a member of the Hydrophilidæ.

The large, cape-shaped sclerite in front of the antenno-frontal sutures is a combination of the front and post-clypeus, namely the *fronto-postclypeus* (fp). This sclerite is folded over the sides of the head and is represented on the ventral side by two triangular regions. The two series of setiferous punctures, each arranged more or less in a semicircle towards the sides of the head, are the *antero-lateral* series (as). Such an arrangement has been termed "lunate" by most authors and is quite characteristic of the species, although in some individuals the punctures are dispersed and often the two series are not entirely symmetrical.

The *anteclypeus* is not usually visible from above, but is a membranous area concealed beneath the cephalic margin of the fronto-postclypeus uniting it with the *labrum* (l). In the genus *Neohydrophilus,* including the American species, *N. castus* Say, the anterior margin of the fronto-postclypeus is so distinctly and broadly emarginate that d'Orchymont, 1913, designated as the clypeus (postclypeus) the membranous area occupying this emargination. Thus he considers the dorsal sclerite posterior to it the prefront (front). It is possible that this area really represents the clypeus but I am still inclined to call it the anteclypeus.

The *gula* (g) is bell-shaped, and as shown in Figure 9, is slightly indented at its cephalic margin. It lies between the postgenæ from which it is separated by the gular sutures and extends from the base of the submentum to the occipital foramen. The *gulo-submental suture* (gss) is continuous with the sutures which separate the postgenæ and the submentum. The *gular pits* (gp) seem to be present along the entire length of the gular sutures but are visible externally only near the cephalic end of the gula. The entire surface of the gula is minutely punctured and pubescent.

Endoskeleton (Fig. 9):—The right half of the tentorium is depicted *in situ* whereas the left half is laid over to the left in order to show its structure more satisfactorily. Each *anterior arm* (aa) has its origin in a frontal pit located near the dorsal condyle and extends in a caudo-ventral direction branching into two arms, one forming the *dorsal arm* (d) and the other uniting with the *posterior arm* (po). The dorsal arms end on the underside of the vertex near the posterior margin of the eyes while the posterior arms are extensive plate-like structures which arise from the gular pits. The caudal expansions of the posterior arms form a sort of collar to the occipital foramen ventrad and laterad but are lacking dorsad. A small spine-like projection is present near the caudal margin of each posterior arm and each occipital condyle or *odontoid process* (od) is evidently represented by a minute sclerite in the membrane of the neck between each pair of lateral *cervical plates* (ip) and the collar of the posterior arms. The *body of the tentorium* (b) is very much reduced and is represented only by a slender transverse bridge connecting the posterior arms. A characteristic but small spine is directed forward from the middle of this bridge.

Labrum and Epipharynx (Figs. 1, 2, and 10):—The *labrum* (l), the most cephalic sclerite of the head, is about four times as wide as it is long. Its cephalic margin is rounded at the sides and is slightly emarginate mesad. A transverse row of setiferous punctures is present near the caudal margin of the labrum and the punctures are irregularly spaced and vary from ten to fourteen in number. A number of scattered setæ are also present at the sides of this sclerite. All the setæ of the labrum, however, are delicate and are often broken off except on fresh specimens. A narrow groove, parallel and slightly cephalad of the caudal margin, marks the attachment of the cephalic border of the *anteclypeus*. The *tormæ* are present as stout, chitinous projections of the caudo-lateral angles of the labrum and are directed caudo-mesad. At each of the caudo-lateral angles of the labrum there is attached a long tendon and these are associated with the muscles which raise and lower the labrum. The oral surfaces of the labrum and epipharynx are quite complicated in structure, and are invested with a variety of spines and setæ. Just inside of the concave margin of the labrum there is an elongate depression bordered in front by a row of about nine spinules (each of which is mounted on a tubercle), and behind by a row of six stout sense cones or blunt spines. At the base of each cone there is a triangular structure. The labrum and fronto-postclypeus are represented on each side by a narrow, sclerotized region which is an extension of their dorsal surfaces. At each side of the labrum there are two small sclerites, the cephalic or larger one bearing a group of setæ while the caudal or narrower sclerite is bare and slightly concave. The rest of this area is entirely membranous except for the *epipharynx* (ep) which is a median, hairy, and somewhat cone-shaped structure.

Antennæ (Fig. 8) :—The 9-segmented, capitate *antennæ* (ant) are inserted in depressions on the ventral side of the head just in front of the eyes. When at rest they are folded back and lie on the under side of the head just below and mesad of the eyes. The bulbular base of the scape fits into an antennal socket thus forming a ball-and-socket type of articulation. The first segment curves inwardly and is somewhat spinous towards its base. The second segment is more slender than the first and is about one-half as long, but it is slightly longer than the next three segments together. The sixth segment is asymmetrical, cone-shaped, and forms a calyx-like structure which receives the seventh segment, i.e., the first segment of the club. Slightly below its distal margin the inner face of the sixth segment is surrounded by a row of small tubercles, each bearing a slender, erect seta. The seventh and eighth segments are similar, tending to be concave on one side but swollen and broadened on the opposite side. The terminal or ninth segment is cordate, flattened, and stalked, as are the two preceding segments. The first six segments are yellowish to brownish and glabrous, whereas the last three, composing the club, are reddish brown and entirely pubescent.

Mandibles (Figs. 3–7, inclusive) :—The *mandibles* (md) are not visible from above except when they are in action. Each mandible articulates with the head capsule on a dorsal condyle (precoila), located on the fronto-preclypeus just in front of a frontal pit, and in an acetabulum (postcoila), situated at the cephalic end of the postgena, by means of a mandibular *acetabulum* (ac) and a mandibular *condyle* (cn) respectively. The *abductor* (ab) and *adductor muscles* (ad), represented in the drawings by tendons, control the action of the mandibles. The mandibles are asymmetrical, although appearing symmetrical at first glance, and have sharply bifid tips, extensive *molar areas* (ma) and *spiniferous margins* (sn). The proximal portion of the molar area is often termed the *submola* and the distal portion the *mola,* but these portions are not clearly defined in this species. The mandibles are stout and remarkably developed for grinding, rasping, and cutting food materials. They resemble more closely the primitive type of mandibles, present in the larvæ of such generalized hydrophilids as *Ochthebius* and *Hydræna,* than they do the more specialized type found in the mandibles of their own larvæ.

The broad, dorsal expansion of the molar area is best seen from a mesal view of the mandible (Fig. 4). The areas marked × are lightly sclerotized and their surfaces are corrugated. The *posteroir piece* (pp) of the mandible is covered with punctures in contrast with the impunctate *anterior piece* (ap). The color of the mandibles varies from piceus to reddish brown.

Maxillæ (Figs. 11 and 12):—The brush-like maxillæ are doubtless very helpful in assisting the mandibles in handling food and each of these "under jaws," as they are sometimes called, consist primarily of a cardo, stipes, lacinia, galea, palpifer, and 4-segmented palpus. The subcordate *cardo* (ca) is the most proximal segment and bears two basal processes. There is a slight indication, just laterad of the outer basal process, of a division of the cardo into a *basicardo* and *disticardo.* The tendon of an adductor muscle is inserted on the larger, inner basal process and the tendon of an abductor muscle is attached to the outer process. That portion lying between the two processes functions as a pivot which is received by a small depression in the side of the submentum just cephalad of the caudolateral angle of the submentum.

The *stipes* is composed of three sclerites, the *basistipes* (bs), the *medistipes* (ms), and the *parastipes* (ps). The basistipes is shaped like a right angle triangle with its base contiguous with the distal end of the cardo and its perpendicular side adjacent to the medistipes along its entire length. The ventral surface and outer margin of the basistipes are rounded and covered proximad with moderately long setæ. The medistipes is notched near its base and, together with the parastipes from which it is weakly separated by a straight suture, forms a somewhat quadrangular area often called the *subgalea.* The mesal margin of the parastipes is concave and the *lacinia* (la), which lies mesad of it, bears a finger-like process or *digitus* (di). The distal margins of the digitus and lacinia are fringed with spines.

Cephalad of the parastipes is the cubical *basigalea* (bg), which is tipped with erect setæ. It bears mesad the *distigalea* (dg), a fan-like structure equipped with eight rows of curved setæ. A peculiar tubular process, arising near the base of the distigalea, is shown in the dorsal view of this region (Fig. 11). The *palpus* (mp) exceeds the head in length and articulates with a cup-shaped *palpifer* (pf) by means of a globular, basal segment. The other three segments are slender and successively shorter distad.

Labium and hypopharynx (Figs. 2 and 13):—The *labium*, sometimes called the "under lip," is attached to the distal end of the gula and postgenæ by means of the *submentum* (sm), which is nearly twice as wide as long. The submentum is shiny and practically flat except for a shallow, circular depression centrally located. This depression is characterized at its base by a triangular, pubescent area of minute punctures. The rest of the plate is only sparsely punctate and each puncture bears a small inconspicuous seta. The postero-lateral angles are somewhat extended laterad and are slightly notched. The *mentum* (mn) is also a broad, quadrangular plate quite similar to the submentum with which it articulates. Its ventral surface is covered with setiferous punctures. The *prementum* (pm) is the membranous area cephalad of the mentum and bears the *ligula* (lg) and the *palpigers* (plg). The *paraglossæ* (pr) and the conical, median *glossa* (mg) comprise the ligula. The paraglossæ appear on the ventral side of the ligula as two subovoid areas, each of which is flattened distad and surmounted by a group of long setæ which exceed the labrum. The sides of the paraglossæ are extended laterad and practically clasp the palpiger from above. Each of the palpigers bears a 3-segmented *labial palpus* (lp). The first segment is short, being about one-fourth the length of the second segment, which is slightly longer than the third. The second segment bears a row of setæ along its inner margin besides several other scattered setæ. Three long setæ are borne laterally on the third segment, a short distance from the tip of the palpus.

The *hypopharynx* is an extremely complicated structure. Its central region is shaped like a triangle with an apex directed caudad. Long setæ are present at the sides of this area and they point inwardly. On each side is a less sclerotized region the surface of which is corrugated with longitudinal grooves. The *fulcrum hypopharyngeum* consists of two round plates lying below the caudal third of the hypopharynx and terminating caudad in two slender arms.

IV. The Cervix

Cervix (Figs. 14 and 20) :—The *neck* (ce) is almost entirely membranous and is usually hidden by the overlapping margins of the prothorax. Dorsad, on each side of the median line, there is a small, transverse area consisting of sclerotized tubercles each of which bears a small seta. Two yellowish *lateral cervical plates* (ip) are present in each side of the neck and together they form a flat, slipper-shaped structure. The cephalic plate or *precervicale* (y, Fig. 20) is rounded at both ends, elongate, and bears cephalad a group of setæ, each surmounting a small tubercle. Just below this area a conical process of the plate is directed inwardly. The caudal plate or *postcervicale* (z, Fig. 20) is about one-third the length of the precervicale. It is pointed at both ends, and is shaped somewhat like a meatchopper. The postcervicale has a slender, dorsal arm which is twisted half way around. MacGillivray, 1923, termed the cephalic plate, the cervepisternum, and the caudal plate, the cervepimeron, since he evidently considered them to be homologous with pleural sclerites. The terms, jugular sclerites, cervical sclerites, and "prothoracic paraptera" have also been used as names for these plates.

V. The Thorax and its Appendages

Prothorax (Fig. 14) :—The dorsum or upper surface of the pronotum is convex, and is nearly twice as long as wide. It is distinctly margined at the sides but only slightly in front and in back. A very narrow groove is present inside the lateral margins and a row of inconspicuous setæ arises from the bottom of the groove along its cephalic half.

The dorsal surface of the pronotum bears six characteristic groups of setiferous punctures which are fairly constant in number and arrangement. Each *antero-external series* is composed of two groups of punctures, an outer group of scattered punctures in the cephalo-lateral angle of the pronotum and an inner group arranged in a nearly straight, oblique line directed caudomesad. The *medio-external series* is scattered irregularly over a large subtriangular area, the apex of which points mesad.

The cephalic border is somewhat sinuate, being concave as a whole but slightly convex in the middle. All of the pronotal angles are rounded, the caudal angles more noticeably so. The entire pronotum is gradually broadened caudad and the width at its caudal margin is one-half again as wide as that at the cephalic margin.

The pronotum extends ventrad in all directions. The actual extent of the pronotum of insects was made considerably clearer by Crampton, 1926, and his interpretation is accepted in this paper. In front the ventral portion of the pronotum is not very extensive, forming only a narrow band, which is closely appressed to the under surface of the dorsum, and is recognized principally by an indistinct line demarking its caudal margin. Ventrad the sides and the lateral portions of the caudal margin of the pronotum reach the coxal cavities, apparently being either fused with the pleura, which are not clearly traceable, or represented by the inflexed regions below the margins of the coxal and trochantinal cavities in the vicinity of the *precoxal folds* (n).

A weakly defined but easily traced *subnotal suture* (in) divides the ventral portions of the pronotum at each side into the so-called *epipleuron* (ei) and *pseudopleuron* (pn). The epipleura are narrow and somewhat L-shaped regions. Each pseudopleuron seems to be divided by a short suture, arising from the lateral end of the trochantinal cavity, into two sclerites, which are often incorrectly designated the episternum and the epimeron.

In the region of the posterior foramen the ventral portion of the pronotum bends slightly cephalad and then caudad forming a horizontal groove and a narrow *shelf* (sh) upon which the anterior edges of the elytra rest. The caudal margin of the shelf is sinuate and fringed with short setæ except towards its sides.

The under side of the prothorax, just inside of the lateral margins, is concave, but mesad the prothorax is noticeably convex, the convexity being limited approximately to a region bounded by lines tangent to the sides of the foramina. The *basisternum* (ba) forms the anterior part of the sternum, and in front a portion of it is bent inwardly at right angles to the rest of the sclerite. The anterior edge of the basisternum is slightly margined ventrad, and the basisternum is prominently keeled along the median line. This keel is laterally compressed and is extended slightly forward as a blunt process. It is pointed caudad and forms a sharp angle with the surface of the *furcasternum* (fs). The lateral extensions of the basisternum are the *precoxal bridges* (pc) and they are separated from the pronotum at each side by the distinct *precoxal sutures* or *folds* (n). In addition to the pubescent hairs covering the basisternum, scattered setæ occur on the cephalic half of its ventral surface.

The furcasternum is just caudad of the basisternum and slants caudo-dorsad so that it is almost entirely concealed by the coxæ. It divides caudad into two, broad, flat arms, each of which passes beneath a coxa in a caudo-lateral direction thus forming the mesal wall of a coxal cavity, and unites with a mesal projection of the pseudopleuron, namely, the *postcoxal bridge* (px). The *furcal pits* (fu), which are situated about midway along the lower surfaces of the furcal arms near the inner margins of the furcasternum, lead to short, internal processes or furcæ. The pointed, mesal projections of the postcoxal bridges are practically contiguous.

Prothoracic leg (Figs. 15–19, inclusive):—When *in situ* the *coxa* (cx) appears to be globular, but when it is removed from the *coxal cavity* (cc) it is seen to be more ovoid than spherical in form. The entire surface of the coxa, except a basal process and a narrow, mesal area where the coxæ are contiguous, is pubescent. The dorsal (extensor) surface of the coxa is prolonged proximad into a *coxal process* (cp) which articulates with a bottle-shaped *trochantin* (tn) by means of a condyle. The trochantin is hollowed out near its proximal end and the sclerite is so divided at its base that two knob-like processes are formed. These processes are so attached to the hidden pleuron that each one of them apparently articulates on each side of a pleural suture. Stout tendons (Fig. 16, te), are attached to the coxal process and the trochantin in such a way as to permit the coxa to rotate freely.

The external relation of the second segment of the leg or *trochanter* (tr) to the coxa is best seen by a glance at Figure 17. The trochanter is an irregular segment but appears oval from below and is pubescent except for a small distal area cephalad and along the apical half of a ventral ridge. Internally two knobbed condyles (trochocondyles) arise from the dorsal surface of each trochanter and extends in opposite directions, i.e., cephalad and caudad, forming a sort of T-shaped structure each end of which articulates with a trochantifer of the coxa. The distal end of the trochanter is not strongly fused with the femur but it does not articulate freely, the union being more or less rigid.

The *femur* (fe) is about the same length as the coxa including the coxal process, and is nearly three times as long as its greatest width. The entire surface of the femur is sparsely punctate except where it is pubescent. Each puncture has a microscopic spine. The pubescence on the caudal side of the femur occurs only near its base, but in front it covers about two-thirds the distal half of the segment. The entire ventral (flexor) surface of the femur is hollowed out, but more noticeably so distad. The caudal surface is flat while the cephalic surface is convex.

The *tibia* (ti) is just as long as the femur if the *tibial spurs* (tis) are included but is more slender. The cephalic surface is distinctly convex whereas the caudal surface tends to be somewhat flattened. There are six, longitudinal rows of spines on the tibia, five of which are visible from a caudal view and the sixth from a cephalic view. The spines of the three middle rows of the caudal side and the row on the cephalic side are stout and conical while the other two or marginal rows (ventral and dorsal) are flattened. These rows of spines give the tibia an appearance of a serrate margin. There are two prominent, angular, tibial spurs, the more dorsal of which is longer and stouter, and a row of flat spines surrounds the distal end of the tibia.

The *tarsus* (ta) is 5-segmented and bears terminally a pair of flat claws or *ungues* (cl). The tarsal segments with the exception of the first, are fringed dorsad with a row of slender setæ which are as long as the first segment of the tarsus. Each tarsal segment is grooved along its ventral surface and the grooves are bordered on each side with a row of short, flat spines. The claws are recurved, sharply pointed, and each one has a basal tooth. The basal teeth are acute in the female but are usually blunt in the male (Fig. 19). The claws are more strongly bent in the male, resembling grappling hooks. The pretarsal region is somewhat angular, giving each lateral portion an appearance of a subbasal tooth. Between the bases of the claw there is a slender, *cylindrical process* (pt), which possibly represents a ventral projection of the pretarsus. This process is sclerotized and bears distad two or three long setæ.

Mesothorax (Figs. 21 and 22, in part; and 24–27, inclusive) :— Dorsally the *prescutum* (psc) is small and triangular, the base of the triangle being in line with the cephalic margin of the mesonotum and the apex attaining the anterior margin of the scutellum. The major portion of the prescutum is inflexed over the deeply emarginate, cephalic margin of the mesonotum. For a short distance it slants in a caudo-ventral direction and then flattens out forming an internal shelf. The prescutum is so folded along the median line of this shelf that it forms a blunt, laterally compressed, spine-like process. The lateral portions of this internal shelf are subtriangular and extend caudo-laterad as far back as the posterior margin of the *scutum* (sc). The caudal extensions of the prescutum are apparently inflexed again and closely applied to the ventral surface of the shelf. At the cephalic border of the shelf this secondary inflection flares ventrad and cephalad forming a pair of narrow, lateral wings which constitute the *prephragma* (Fig. 25, ph).

The dorsal surface of the *scutellum* (sl) is a prominent, triangular, raised area and, in keeping with the rest of the upper surface of this species, is minutely punctate and shining. It is approximately equilateral and extends below on all sides, slanting mesad as far as the triangular region shown in Figure 25 by interrupted lines. In front, just below the margin of the scutellum, there is a row of short setæ.

The *scutum* (sc) is divided into two irregular areas by the prescutum and scutellum. Each of these lateral areas extends from the cephalic margin of the mesonotum to the anterior margins of the *parascutella* (prs). Cephalad the scutal regions are pubescent and somewhat arched. The slender antero-lateral extensions of the scutum are known as the *prealar bridges* (prt). The prominent lateral angles, two on each side of the scutum, are the anterior notal processes or *suralares* (anp) and the posterior notal processes or *adanales* (pnp) which support the elytra. On each side just below the region of the two notal processes is a round concavity, the diameter of which is equal to the distance between the processes. The margin of the scutum between the adanale and the parascutellum is noticeably notched above and concave laterad.

At each side of the notum, arising as a lateral extension of the arm-like parascutellum, is an *axillary cord* (axc). Near the base of each axillary cord, a narrow projection, apparently a remnant of a *postalar bridge* (pb), is given off from the caudal margin of the parascutellum and extends in a latero-ventral direction. The parascutellum is slightly concave in the region adjacent to the scutellum.

The *postscutellum* is continuous with the caudal margins of the parascutellar sclerites but is so inflexed that it lies entirely beneath the mesonotum and its caudal margin extends as far forward as the cephalic limits of the parascutella (indicated by dotted lines). The postscutellum is slightly sclerotized and would be called triangular in shape except for the fact that it is truncate and emarginate caudad.

The pleural and sternal regions of the mesothorax are better developed than the tergal portions and are quite rigidly united with the corresponding portions of the metathorax. The cephalo-lateral angles of the mesosternum and the cephalic regions of the pleura are rather complex so that it is a difficult proposition to name the parts with certainty. These areas are hollowed out for the reception of the cephalic portion of the lateral margin (lm), the apophysis (ae), and the notale (nt) of each elytron. It is very likely that the dorsal side of the lateral margin, a narrow ridge, represents the *alifer* (wing process, wp) and that the ventral side, a projection rounded laterad and bent dorsad, is the anepisternum but one can not be positive.

The cephalic margin of each pleuron is bounded by a transverse, emarginate sclerite, the *prepectus* (pe). These sclerites are narrowly separated mesad by the basisternum (ba). Laterad each prepectus bears a flat, triangular process projecting forward from its cephalic margin. The name of this process, as well as its function, is a question but it may be of value in supporting the *mesothoracic spiracle* (sp 1), which lies in the intersegmental membrane just in front of the process. A group of setæ is present ventrad on the pro-mesothoracic intersegmental membrane between the two spiracles. Internally each prepectus is represented in front by a narrow inflexed portion, which is closely applied to its surface. The suture, which separates the caudal margin of each prepectus from the katepisternum (ket), is sinuous.

As usual the pleural suture divides each pleuron into an episternum and epimeron. When either the episternum or the epimeron is divided into an upper and a lower region, the prefixes "an" and "kat" are used respectively to denote such regions. These terms were first proposed by Crampton, 1909, and he also discusses their usage in a later paper, 1914.

The *katepisternum* (ket) or lower portion of the episternum is the largest sclerite of the pleuron and is somewhat quadrangular, although its inner side is convex. The *pleural suture* (su) evidently originates at the cephalo-lateral angle of the prepectus, and as a faint ridge extending caudad forms the lateral boundary of the prepectus. It passes caudad along the side of the body until it reaches a point about half way along the mesal margin of the anepimeron (aer). Then it takes a direction almost at right angles to its previous course and travels caudomesad, finally dividing the *coxifer* (Fig. 21, cf) and attaining the *coxal cavity* (c.c).

The *katepimeron* (ker), the lower portion of the epimeron, is about one-third the size of the katepisternum and irregular in shape. It is emarginate behind and slightly conceals the cephalic margin of the metathoracic katepisternum (ket). Ectad the *anepimeron* (aer) or upper portion of the epimeron is triangular in shape and its broad base borders the katepisternum and katepimeron laterad. An internal view of the anepimeron (Fig. 21, aer) shows that dorsad it is reflexed for a short distance and tends to cover the inner surface of the katepimeron (ker).

The *basisternum* (ba) extends from the cephalic margin of the mesosternum caudad to a point between the *coxæ* (cx) almost in line with their caudal margins. The basisternum is prominently keeled along the entire median line and is interlocked at its caudal extremity with the *metasternal keel* (mek). The *mesosternal keel* (msk) is right angled in front and compressed laterad for about one-fifth its length from the cephalic margin. The remaining portion of the keel is rounded below except in front where it bears a small, round tubercle. The sides of the keel slope gradually and each side takes the form of a triangular area extending as far laterad as the inner margin of the katepimeron, thus forming an *antecoxal bridge* (pc). The *furcasternum* is entirely concealed below the outer surface of the mesosternum but is seen at the cephalo-mesal margins of the coxal cavities when the *coxæ* (cx) are removed. When the sternum is viewed from within it is seen that the *furcal arms* (Fig. 21, ft) constitute the most evident endoskeletal structures of the mesothorax. These arms are slender, rod-like processes, one on each side, arising from the *furcal pits* (fu), located at the cephalo-mesal angles of the *coxal cavities* (cc). Each one extends dorsad in a cephalo-lateral direction to a region between the episternum and epimeron where it flares out like a trumpet to form a terminal muscle disc. The furcae are somewhat flattened near their origin and are united with each other ventrad by a short bridge. The caudal surface of each furca bears a muscle disc a short distance from its base. The cephalic margins of the *precoxal bridges* (pc) and the sides of the *basisternum* proper (ba) are invaginated, forming on each side a subtriangular shelf, the caudo-mesal angle of which extends caudad to the base of the furcal arms.

A peculiar infolding or *apodeme* (ag) occurs along the upper margin of each katepisternum and extends from a region near the end of each furcal arm to the caudal margin of the prepectus where it terminates in a finger-like projection. The peritreme or sclerotized area around the *metathoracic spiracle* (sp 2) is shown in its normal position just inside the katepimeron (ker).

Elytra (Figs. 24, 26, and 27):—The elytra cover the entire dorsal surface of the body behind the caudal margin of the pronotum with the exception of the mesoscutellum. They are strongly convex and closely follow the general contour of the body. The length of each is about two and a half times its width. The *scutellar margins* (slm) of the elytra are contiguous with the mesoscutellum, and when at rest the posterior or *sutural margins* (pi) of the elytra are interlocked, a narrow ridge of the right elytron fitting into a groove of the left elytron. The proximal and anterior or *lateral sides* (lm) of the elytra are margined.

Each *apophysis* (ae) of the elytron articulates by means of an axillary plate, the *notale* (Figs. 22 and 24, nt), with the concavity at the cephalo-dorsal angle of the mesopleuron. There are eleven longitudinal rows of small punctures, which are faintly visible on the upper side of each elytron, and four or more longitudinal rows of larger, setiferous punctures. The first two rows of the smaller punctures unite about one-third the distance of the length of the rows from the proximal margin and the eighth and ninth rows form a single row for a short distance from the base of the elytron and then separate.

When viewed with a hand lens, there appear to be about four rows of distinct punctures and these are comprised of the larger, setiferous punctures just mentioned. They lie between the third and fourth, fifth and sixth, seventh and eighth, ninth and tenth rows, and laterad of the eleventh row of smaller, indistinct punctures. The third row is somewhat irregular and missing proximad while the fourth row is also irregular and really composed of two or more confused rows.

The latero-proximal angle of each elytron bears an oblique row of setiferous punctures and a few, delicate setæ. A number of spine-like setæ are scattered along the proximal margin and the ventral surfaces of the inflexed margins are covered with a stiff pubescence except for a narrow strip along the lateral margin.

A delicate membrane lines the inside of the elytron. The small, dorsal punctures are represented ventrad by short rod-like projections but the larger punctures are not extended below and appear as small pin-holes.

The *jugalula* (Figs. 24 and 26, al) is a small, flat, membranous, sac-like appendage attached laterad to the inflexed, basal margin of each elytron, and to a small, articulating ossicle, the *notale* (nt). The notale fits into the cavity of the *elytral apophysis* (ae) and serves as an intermediate articulating ossicle between the apophysis and a cavity in the mesopleuron. The notale is somewhat hammer-shaped, and it is possible that its claw-like base may be composed of more than one axillary sclerite. The jugalula appears to be slightly sclerotized proximad and along its *elytral* (em) and *notal margins* (nm). The jugalula is reversed in position when it is folded back against the body, in which position its dorsal surface lies next to the notum. The *axillary cord* (axc), which originates as a part of the caudal margin of the parascutellum, extends to the notal margin of the jugalula near its base.

A small muscle, represented in Figure 24 by a *muscle disc* (mu) and a tendon, is attached to the jugalula mesad of a small, triangular *axillary sclerite* (i), while another larger sclerite, probably the *basanale* (be), lies on the dorsal surface of the jugalula just laterad of the small axillary sclerite (i).

Mesothoracic leg (Fig. 29) :—The mesothoracic leg is somewhat longer than the prothoracic leg, the principal difference being in the greater length of the mesothoracic tarsus. The elongate, subtriangular *trochantin* (tn) is inserted in the cephalic face of the coxa and is only visible externally for about half its width. The portion, in front (ventrad) of a longitudinal ridge, is concealed beneath the precoxal bridge (pc).

The *coxa* (cx) is conical but its dorsal half, except distad, is flattened cephalad (below) and margined along its cephalo-dorsal edge. It is deeply emarginate where the trochantin replaces its cephalic face ventrad (flexor surface). The coxa is more or less fixed in a transverse position with its distal end directed mesad and rotates only on its longitudinal axis. Both the coxa and trochantin are entirely pubescent and the trochanter is pubescent except for a triangular, apical area on its cephalic face.

The *trochanter* (tr) is a small, irregular, compressed segment and is practically fused to the femur. The method of articulation is similar to that occurring with the prothoracic trochanter.

The *femur* (fe) is nearly three times as long as its greatest width and is about the same length as the tarsus. It is laterally compressed, rounded dorsad, and grooved ventrad. This ventral groove is shallow and flattened at its bottom and becomes deeper and wider distad. The caudal surface is smooth and bears only an occasional puncture but the cephalic and dorsal surfaces are entirely punctate, each puncture bearing a microscopic spine.

The *tibia* (ti) is shorter, more slender than the femur, and its caudal surface is flattened. The caudal spur is nearly half again as long as the cephalic and almost as long as the first two tarsal segments. The rows of spines are not clearly defined but there are about eight longitudinal rows, only two of which are caudal, and these are practically marginal. Cephalad the tibia is fringed distad with a row of stout spines, while caudad and set back from the distal margin there is a curved row of slender spines.

The *tarsus* (ta) is the longest portion of the mesothoracic leg and each of its five segments, except the first, bears a dorsal fringe of long setæ (swimming hairs) which vary distad in length from approximately 2.0 mm. at the base to 0.45 mm. The second segment is about twice as long as the first and is equal to the third and fourth together. The terminal segment exclusive of the claws, which are half as long again, is three-fourths the length of the second segment. All of the tarsal segments except the first are grooved ventrad along their entire length, and the grooves are bordered on each side with a row of short, flat spines. There is a slight indication of a ventral groove on the first segment due to the presence of two distal rows of flat spines. This segment is deeply emarginate above and the base of the second segment fits into this emargination, the rest of the first segment tending to clasp the base of the second. The entire tarsus is laterally compressed.

The *claws* (cl) are similar to those of the prothoracic legs. The secondary sexual characters are not so pronounced, although the basal tooth is usually blunt in the male. Each claw has a subbasal and basal tooth and the usual *pretarsal process* (pt), which bears two or three apical setæ, is present.

Metathorax (Figs. 21 and 22, in part; and 23):—The *metanotum* is twice as wide as long and is quite complicated in structure. The *prescutum* (psc) is divided into a cephalic surface, which extends downward at nearly right angles to a more caudal or dorsal surface. The cephalic surface of the prescutum is somewhat semicircular, lightly sclerotized, and bears two, small, semicircular flaps, the *prephragma* (ph) on its ventral margin. The meso-metathoracic intersegmental membrane is attached to the caudal margin (''antecostal suture'') of the cephalic region of the prescutum so that this region is entirely internal. Some authors consider that this cephalic surface of the prescutum is the prephragma.

The dorsal surface of the prescutum (psc) is cape-shaped, strongly arched, and its heavily sclerotized, lateral portions are separated by an almost membranous median area. This central area is broad and reaches from the so-called antecostal suture caudally to the cephalic margin of the scutellum (sl). The latero-cephalic prolongations of the prescutum form the *prealar bridges* (prt) and the lateral end of each bridge is rolled up and also has a ventral, spine-like projection, the tip of which is barely discernible from above, but may be seen in Figure 23 just mesad of the rolled-up area.

When in position the prescutum is almost entirely covered by the caudal portion of the mesothoracic dorsum, and the apex of the mesoscutellum attains the cephalic margin of the median groove (me).

The *scutum* (sc) constitutes the main part of the mesonotum, and is separated mesad by the scutellum (sl) into two subquadrangular areas. There is a tendency for each of these lateral areas to be divided in the region of a narrow, pubescent band into a cephalic and a caudal portion. This band is more or less included between the two dotted, transverse lines shown in Figure 23. The cephalic of these two areas is roundly elevated and slightly higher than the caudal area, and attains the lower level of the caudal area just behind the pubescent band. Each cephalic scutal region bears a pubescent, mucronate tubercle laterally.

An *anterior pronotal process* (anp) projects from beneath each of the cephalo-lateral angles of the scutum, and is a conspicuous, flat, trapezoidal structure slightly emarginate distad. The first axillary sclerite or *notale* (nt) lies just laterad of the anterior notal process. It is an irregular sclerite with a neck-like process, which extends cephalo-laterally to the base of the subcostal vein of the hind wing. At the side of the notale, and lying slightly beneath it, is another irregular sclerite, the secondary axillary sclerite or *median ossicle* (mo). This ossicle is probably composed of a proximal and an intermediate median ossicle and its lateral margin is shaped somewhat like a thumb and forefinger in outline, the cephalic or finger-like process of which is continuous with the base of the radial vein.

Each lateral margin of the scutum is noticeably indented so that, together with the caudal margin of the notale, an oval, membranous area is enclosed. The third axillary sclerite or *basanale* (be) is attached to a small flap of this area in such a way that an elbow-like projection fits into the scutal indentation when the wing is at rest. The basanale is an angular sclerite, the lateral margin of which is attached to the anal region of the hind wing, while its inner margin is contiguous with the side of the dorsum.

The cephalic margin of the *posterior notal process* (pnp) forms the caudal margin of each lateral indentation of the scutum and its lateral margin, where it unites with the basanale, is entirely straight. Just below the anal region of the wing in this area, a large, flat, suboval sclerite, the *subalar plate* (sul) is more or less embedded in the membrane. A large muscle disc is attached to its inner surface.

Two, convergent, *scutellar ridges* (sr) extend from the cephalic margin of the scutum nearly as far back as the caudal margin of the scutellum (sl). The ridges are so folded over mesad that each forms a groove which serves to receive the inflexed margin of an elytron.

The *scutellum* (sl) is the subtriangular sclerite between the two scutal areas. It would be difficult to describe all of its limits because it is so closely united to the scutum. The arms of the scutellar ridges are doubtless formed from the scutellum although continuous with the scutum. Between the scutellar ridges is a *median groove* (me) upon which the inflexed sutural margins of the elytra rest, thus allowing the elytra to fit flush with the raised portions of the dorsum. Certain regions, where the scutum and scutellum unite, are so invaginated that they form an X-shaped, centrally located, internal structure called the *endodorsum* (ed). The caudal margin of the scutellum is undulating and slightly lobed just behind the median groove.

The *postscutellum* (psl) is a narrow sclerite contiguous with the caudal margins of the scutellum and the scutum. It extends entirely across the dorsum and its projecting lateral arms are the *postalar bridges* (pb). Along the cephalic margin of the postscutellum, just caudad of the scutellum, is a narrow membranous area shaped in outline like a bird with outstretched wings. Caudad the postscutellum is bent perpendicularly downward, forming internally a transverse *postphragma* (pph), the lateral ends of which bear a prominent muscle disc. The postphragma is divided on each side, about midway between the median line and the muscle disc, by a longitudinal fold in the postscutellum. The broken line in Figure 23 indicates the caudal limit of the postscutellum as well as the basal line of the postphragma. The narrow region behind this line probably represents an isolated portion of the first abdominal tergite.

The *metapleuron,* except for the katepisternum and the caudal end of the katepimeron, is concealed from view by the elytron. When viewed from below the *katepisternum* (ket) is subovate with its caudal end somewhat narrower than its cephalic. It is almost three times as long as it is wide and extends lengthwise from the posterior margin of the mesepimeron to the metathoracic coxa (cx). The caudo-dorsal angle of the katepisternum has been bent upward for a short distance and then ventromesad, forming with a caudo-ventral portion of the katepimeron (ker) an *internal,* triangular *shelf* (ks). The original pleural suture has naturally been carried internally with this invagination so that the external line of demarkation, which divides these two sclerites and which I have called the *pleural suture* (su), is really not a true pleural suture.

The *anepisternum* (aet) adjoins the cephalo-dorsal angle of the katepisternum and is a slender arm-like sclerite which forms the cephalic portion of the *wing process* (wp). The *katepimeron* (ker) is the narrow, curved sclerite contiguous with the dorsal margin of the katepisternum. Caudad it is emarginate where it borders the coxal cavity and its caudo-dorsal angle is pointed. The cephalo-dorsal angle of the katepimeron is noticeably emarginate where it is replaced by the *anepimeron* (aer). The suture dividing these two portions of the epimeron is poorly defined but the division may be clearly recognized by the fact that the lower portion of the anepimeron is only lightly sclerotized in contrast with the more heavily sclerotized katepimeron. The anepimeron is sharply bent at the side of the body and extends to the dorsal surface of the insect. This dorsal portion is subtriangular and its apex is more heavily sclerotized than the rest of the sclerite, especially between the dotted lines shown in Figures 21 and 22.

The caudal or upper portion of the wing process (wp) is a slender extension of the anepimeron and it can be plainly seen from the internal view that the true pleural suture really divides the wing process into the episternal and epimeral portions since it takes a direct course to the *pleural coxal process* (cf). Above the wing process and attached to the anepisternum near its base is a large *muscle disc* (mu).

The *subalar plate* (sul) is shown in the membrane of the dorsal side of the body just mesad of the anepimeron, and the line of attachment of a muscle disc on its ental surface is represented by a broken line (Figure 22). The *first abdominal spiracle* (sp 3) is shown just behind the *postalar bridge* (pb), which intervenes between the spiracle and the anepimeron.

The largest sclerite of the entire *sternum* is the *basisternum* (ba) of the metathorax. It extends from the inner margin of the katepisternum on one side in a ventro-mesal direction to the median line, and then in the reverse direction to the inner margin of the katepisternum on the other side. Each lateral portion is somewhat quadrangular but in front it is concavely emarginate since it follows the contour of the mesothoracic coxa. Mesally the basisternum bears a stout, ventrally flattened *keel* (mek), which is slightly grooved along the caudal half of its median line, not including the terminal *"metasternal spine"* (mts). This spine is compressed towards the tip and has a sharp, longitudinal ridge below. It does not extend beyond the hind coxæ (cx), in contradistinction to the condition occurring in such genera as *Hydrous* and *Tropisternus* in which the spine is noticeably prolonged.

The *furcasternum* (fs) is represented by two transverse sclerites, commonly called the antecoxal pieces or precoxal bridges. The cephalic margins of these sclerites, together with the caudal margins of the basisternum on each side of the keel, are invaginated to form a flat, narrow apodeme. The caudal margins of these furcasternal sclerites are reflexed, closely appressed to the inner surface of the furcasternum, and extend forward as far as the cephalic margins of the furcasternum.

The body of the *furca* (fs), a stout and deeply 4-grooved, internal structure, arises at the posterior end of the metathorax just above the metasternal spine. It extends in a cephalo-dorsal direction giving off two latero-dorsal arms, each of which bears two prominent muscle discs. One of these muscle discs is terminal while the other occurs just before the tip. The furca is of such a length that, if it were laid down flat on the metasternum, its most cephalic, 3-pronged tip would attain the base of the mesothoracic furca. The base of the furca is divided mesally so as to form two, longitudinal processes or *furcal condyles* (cn), upon each of which the ventro-mesal acetabulum of each coxa articulates.

The *wings* (Fig. 28) :—Forbes, 1922, aptly described and discussed the venation of the Hydrophilidæ, which he placed in accordance with Gahan's system (1911) in the Palpicornia (Ganglbauer). He included the wings of *Hydrous triangularis* Say, *Hydrocharis* (*Hydrophilus*) *obtusatus* Say, and *Sphæridium scarabæoides* L. among his figures. For some reason or other, Forbes failed to figure the veins, present at the tip (apical veins) of the *Hydrophilus* wing, with the same degree of detail as he did in the case of *Hydrous.* The apical veins are weakly defined in *Hydrophilus,* to be sure, but are just as weakly defined in *Hydrous.* If viewed under the proper kind of illumination and from the right angle, one can not fail to observe a venation similar to that which Forbes depicted in *Hydrous.* It may be possible that he really saw the apical veins of *Hydrophilus* but considered them to be too indistinct to figure. The fact that he bases the apical venation of his hypothetical type on *Hydrophilus* suggests that he may have really recognized the condition in *Hydrophilus obtusatus.* However, he used the generic name, *Hydrocharis,* in discussing *Hydrophilus obtusatus.*

In general, Forbes' ideas relative to the naming of the veins seem to be well founded and I have therefore accepted his interpretations in this paper. Nevertheless, I have been forced to borrow the names, which he used for *Hydrous,* in labeling certain of the veins of *Hydrophilus,* more particularly the branches of *Radius* (R) and *Media* (M). There may be some question regarding the vein which I have designated as R_4. Forbes apparently calls this vein R_3 in his figure of the wing of *Hydrophilus* (*Hydrocharis*). However, if one refers to Forbes' accurate drawing of the *Hydrous* wing it will be seen that R_2 is fairly well defined. This R_2 seems to be represented in *Hydrophilus* by the stub-like vein towards the base and posterior to R_1. If then this stub-like vein is R_2, then the next fairly well defined vein, posterior to R_2, is probably R_3, and in turn the one which Forbes called R_3 is really R_4. In *Hydrophilus* R_4 and R_5 fork clearly, as is shown in Figure 28, so I believe R_4 is properly located.

The Palpicornia have a complex apical venation and Forbes states that it is the only group of Coleoptera with a complex apical venation. Moreover, it is apparently the only polyphagan group which preserves traces of the radial cell beyond the transverse fold. The preservation of M_4 and Cu as separate veins is important since such a condition tends to link the Palpicornia with the lower Adephaga. One of the anals ($2A_1$) is always lost.

Both Tillyard and d'Orchymont have contributed important views relative to the hydrophilid venation. Tillyard, 1926, states that the closed cell present in the Adephaga between *Media* (M) and *Cubitus* (Cu), namely the oblongum, is absent in the Polyphaga and calls the formation, which replaced it, the apertum. The incompletely chitinized vein, *Media* (M), is called by Tillyard the "returning vein." In *Hydrophilus obtusatus* the apertum is well developed and the cross vein, cu–a, is noteworthy.

The folding of the polyphagan wing when at rest was very nicely worked out by d'Orchymont, 1921, who some years ago kindly forwarded me a reprint of his paper, together with an interesting paper model. The important folds, which occur in the hydrophilid wing, include the convex anal and median folds, the concave median furrow, and the transverse folding according to d'Orchymont. Forbes, 1922, gives a diagram showing the folding which occurs in *Hydrous triangularis* Say. I have not figured the folding pattern of the *Hydrophilus* wing since I find it similar to the folding in *Hydrous.* According to Forbes "the folding at the costal margin is as in the Adephaga while the remainder of the wing is almost typically polyphagan."

Metathoracic leg (Fig. 29) :—The metathoracic leg is by far the longest of the legs, each segment being as long or longer than any corresponding segment of the other legs. The trochantin is not present but the *coxa* (cx) is exceedingly well developed, the two coxæ together spanning the entire ventral side of the body included between the lateral margins of the elytra. The coxa is about four times as long as it is wide and it can rotate only forward and back on its longitudinal axis. Articulation is by means of the pleural *coxal process* (Fig. 21, cf) and the *furcal condyle* (Fig. 21, cn), which fit into a ventro-lateral (proximal) and ventro-mesal (distal) acetabulum respectively. The caudal surface of the coxa is convex, and, when at rest, lies entirely below the level of the ventral surface of the body. The flat, cephalic surface of the coxa is flush with the under side of the body. It is attached to the posterior surface of the thorax along its ventral (flexor) face. A longitudinal ridge is present along the ventral margin of the cephalic surface of the coxa and the dotted line, shown in Figure 30, indicates its dorsal limit. The coxa is entirely pubescent while the trochanter (tr) is pubescent except for a triangular, apical area on its cephalic face.

The *trochanter* (tr), *femur* (fe), *tibia* (ti), and *tarsus* (ta) are practically identical in structure with the corresponding parts of the mesothoracic legs. The trochanter is not quite as strongly compressed as the mesothoracic trochanter. The femur, which is nearly as long as the coxa (cx), is slightly more than twice as long as its greatest width. Some individuals seem to show less punctuation on the cephalic surface of the femur but still others agree in punctuation with the mesothoracic femur. The *tibial spurs* (tis) are slightly longer than those of the mesothoracic legs, the caudal spur attaining the distal margin of the second tarsal segment, but they bear the same ratio to each other.

The *tarsus* (ta) is exactly the same length as the mesothoracic tarsus and agrees in all of the essential details except that it appears somewhat stouter in certain individuals and the first segment is better defined.

VI. The Abdomen and its Appendages

The *abdomen* (Figs. 31–38, inclusive):—Ten abdominal segments are represented in this species, and, when retracted, their length is about two-fifths of the entire length of the insect. The abdomen is entirely covered dorsally by the wings, which lie under the elytra. Normally there are five visible sternites (s 3–s 7) and the removal of the wings reveal eight tergites (t 1–t 8) and five pleurites (p 3–p 7). The first sternite is missing and the second is hidden beneath the metathoracic coxæ. The eighth abdominal segment is so attached to the seventh by an intersegmental membrane that it can be retracted within the seventh segment in a telescopic manner. In a similar way the ninth segment, which contributes the main portion of the genitalia, is capable of being retracted within the body when at rest. The dorsum is convex and tends to be keeled along the median line while the venter is somewhat concave at the sides but convex mesad. The abdomen of the female is noticeably broader and less acute caudad than that of the male and the cephalic margin of the eighth sternite of the female is more strongly lobed than that of the male.

Tergites (t) :—The first six tergites are soft and slightly sclerotized while the seventh and eighth tergites are fairly well sclerotized, due possibly to the fact that they are more often extended beyond the tips of the elytra. Each of the second to sixth tergites has a setiferous, punctate, transverse area across its caudal half and bears a shallow, round pit just inside its lateral margin.

The exact limits of the tergites are somewhat difficult to locate, especially when the abdomen is boiled in caustic potash, because of transverse thickenings, one of which extends nearly across each of the second to sixth tergites (Fig. 32, dotted lines). The actual segments are delimited by intersegmental membranes, which cause the tergites to appear as folds. The remnant of the first abdominal tergite (Fig. 23, rt), attached to the metathoracic postscutellum is not shown in Figure 31. The rest of the first tergite, separated from the remnant by an intervening membrane, is narrow, roundly notched in front, and deeply emarginate laterad. The two, lateral, sclerotized flaps are characteristic of this tergite. The second tergite is the widest (cephalic to caudal) and longest (side to side) of all the tergites and is chiefly characterized by a thickening across its cephalic third. Towards each side this thickening curves in a cephalo-lateral direction and ends at the cephalo-lateral angles. On each side of the median line two short arms of the thickening extend caudad.

The third to eighth tergites, inclusively, become narrower and shorter caudad, the fourth, fifth, and sixth being approximately equal in width. The seventh and eighth tergites are minutely punctured and pubescent and the seventh tergite has an almost bare, suboval, raised area about one-half the distance between the median line and each side of the tergite near its cephalic margin. A narrow region along each side of the eighth tergite is sparsely pubescent and the sides are slightly inflexed.

Pleurites (p) :—The *pleural membrane* (plm) unites the outer margin of the tergites with the inner margin of the pleurites and is continuous with the intersegmental membranes. These sclerites merge indistinguishably with the pleural membrane and their limits are not always clearly demarked. The pleurites are narrow, pubescent, sclerotized regions, lying adjacent to and above the sternites, and occur on the third to seventh abdominal segments.

Sternites (s) :—The entire ventral surface of the abdomen (venter) as well as the dorsal extensions of the second to seventh sternites, inclusive, are pubescent. The second sternite is narrow, slightly sclerotized ventrad but is represented laterally and dorsally by a small, fairly well sclerotized semi-thimbleshaped sclerite (s 2).

The third sternite is reflexed and noticeably hollowed out on both sides to form the caudal portions of the metathoracic coxal cavities. A divided, median keel is formed between the two cavities and this tends to separate the coxæ. The sternites become gradually shorter caudad and the fourth to sixth, inclusive, are subequal in width. The cephalic margin of each sternite, except the second and third, slightly overlaps the caudal margin of the preceding sternite (see broken lines in Figure 31). The caudal portion of the seventh sternite is reflexed and closely appressed to its upper surface. This reflexed surface is glabrous and shiny except at its caudal margin, where it is pubescent.

Genitalia:—In this species the genitalia consist of portions of the ninth abdominal segment although some morphologists would probably include the eighth. The eighth segment has therefore been figured together with the genitalia proper in order to show its relationship to the other terminal abdominal segments. The interpretation of the genital structures of the Coleoptera is still somewhat of a problem although steps in the right direction have been taken by Sharp and Muir, 1912; Newell, 1918; Muir, 1924; Pruthi, 1924a, b; and Tanner, 1927.

In general the views of Sharp and Muir, 1912, for the male, and Tanner, 1927, for the female, have been accepted for this paper. The main difficulty has been relative to the location and proper naming of the tenth tergite. Newell, 1918, separated the dorsal plate, which I call the ninth tergite (t 9), into a ninth and tenth. It is possible that some portion of this sclerite is really the tenth tergite, but I can not see any good reason for naming the slightly sclerotized portion of this tergite the tenth tergite, as Newell does.

Pruthi's excellent treatises, 1924 a and b, on the postembryonic development of a tenebrionid have helped materially in deciding the homologies of the various genital appendages as well as the questions concerning the position of the tenth tergite. Pruthi interprets the anal segment as the tenth, as does Muir, 1924, and this seems the most logical conclusion.

Female (Figs. 33–35, inclusive) :—The *ninth tergite* (t 9) is a somewhat circular plate, concavely emarginate in front and with a large, slightly sclerotized, more or less central area. The heavily sclerotized lateral arms of this sclerite almost touch each other caudad. According to Newell, 1918, this central area represents the tenth tergite while Tanner calls the entire plate the proctiger, which morphologically is the dorsal plate of the tenth or anal segment.

On each side of the ninth tergite is the subtriangular sclerite or *surstylus* (ss) of Crampton, 1929. These were called the paraprocts by Tanner, but since they are really appendages of the ninth segment can not be so termed. The surstyli are slightly sclerotized caudad and are connected ventrad to the "*valvifers*" (vf) by a bridge which is only slightly sclerotized caudad. According to Crampton, 1929, the so-called "valvifer" in some Coleoptera may be a detached portion of the coxite (c). It is an irregular sclerite which is notched caudad. This *notch* (vn) fits over the coxite in such a way that it forms an articulation point (pivot of Balfour-Browne, 1909).

The *coxite* (c) is composed of two portions, a basal, irregular portion and a slender, finger-like, apical portion, which bears a terminal stylus. The *stylus* (st) is cylindrical with a recurved apical seta. Ventrad the *ninth segment* is terminated by a structure which Balfour-Browne, 1909, called the *ventral grooved plates* (vp). These plates form an apparently paired structure the parts of which are fused along the median line and are grooved dorsally to receive the coxites when at rest. The plates are slightly sclerotized except for a narrow lateral band near their base and for the region along the ventral median line, but even these areas are not heavily sclerotized. The caudal margin of each groove is bordered with fairly long setæ.

According to Balfour-Browne, 1909, muscles attached dorsally to the bases of the spinnerets (coxites and styli) draw back the spinnerets and they pivot on the "valvifers." In the state of rest the spinnerets are concealed for about one-half their length by the immovable grooved ventral plates.

Male (Figs. 36–38, inclusive) :—In the male there is a *dorsal plate* (t 9) similar to the one present on the ninth tergite of the female. The main difference in this dorsal plate depends upon the fact that, in the male, it is united with the lateral plates of the ninth abdominal segment. Each lateral plate extends below and is joined by means of a *cephalo-ventral arm* (h) to the posterior end of an *eversion rod* (vr) lying in the *connecting membrane* (cm) on each side of the ninth sternite (s 9). The *ninth sternite* (s 9) is rounded, weakly sclerotized at both ends, and notched laterally just beyond its middle.

According to Pruthi, 1924a, the *median lobe* (ml) together with its *dorsal plate* (k) constitute the *aedeagus* while the *lateral lobes* (ll) are homologous with the *parameres*. Pruthi's very valuable researches on the larva and pupa of *Tenebrio molitor* L. showed that the median lobe and the lateral lobes developed from an originally single pair of appendages in the region of a genital pocket between the ninth and tenth sternites. The basal piece or *tegmen* (bp) also develops in this region as an evagination of the bottom of the genital pocket during pupation.

The *ejaculatory duct* (j) arose from the fusion of the originally paired median lobes along the entire extent of the aedeagus. The gonopore or *median orifice* (to) of the ejaculatory duct is located ventrally at the caudal end of the median lobe. A strengthening *ring-like sclerite* (f) surrounds the gonopore and a *ventral rod* (r) extends from the cephalic margin of the median orifice along the mid-ventral line about as far cephalad as half the length of the median lobe.

Spiracles (sp):—The structure of the spiracles really calls for an additional study since they are so intricate and important in the life of this water beetle. Brocher, 1912, made an excellent contribution to this phase of the problem when he reported his anatomical and physiological studies on *Hydrous piceus* L.

The position of the first three spiracles has already been described but for the sake of clarity will be repeated here. The first or *mesothoracic spiracles* (sp 1) are located ventrally in the intersegmental membrane between the pro- and mesothorax, and the opening is closely guarded by feathery prolongations. The second or *metathoracic spiracles* (sp 2) consist of simple, annular peritremes with no guarding structures. Each lies in the membrane just above the mesothoracic katepimeron. The third spiracles are the *first abdominal pair* (sp 3) and they have assumed a dorsal position in the membrane just laterad of the first tergite and behind the postalar bridges (pb). According to the researches of Brocher, 1912, the function of the first pair of spiracles is primarily for inspiration since they are best fitted for filtering the air on account of their guarding prolongations. The second and third pairs, being deprived of all protective structures at their entrances, were considered by Brocher as mostly expiratory. However, *Hydrophilus obtusatus* has short prolongations at the openings of the third spiracles (Fig. 22, sp 3). According to Brocher the rest of the spiracles, not including the seventh and eighth abdominal spiracles (sp 9 and sp 10) to which Brocher does not refer, are both inspiratory and expiratory but probably are rarely inspiratory on account of their less developed prolongations.

The spiracles of the *second to sixth abdominal* segments (sp 4–sp 8, inclusive) are dorsal and lie in the pleural membrane (plm) on each side of the second to sixth tergites inclusive. They diminish slightly in size caudad and are rounder than the first three spiracles. The *seventh abdominal spiracles* (sp 9) are very small and almost impossible to find as are the *eighth* (sp 10) which are merely sclerotized tubercles. The former are just laterad of the seventh tergite while the latter are at the sides of the intersegmental membrane between the seventh and eighth abdominal segments (Fig. 35, sp 10). It is probable that these last two pairs of spiracles are non-functional.

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ABBREVIATIONS ON PLATES

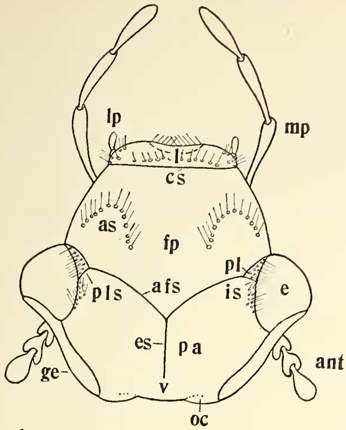
A Anal vein
a anal cross vein
aa anterior arm
ab abductor
ac acetabulum
ad adductor
ae elytral apophysis
aer anepimeron
aet anepisternum
afs antenno-frontal suture
ag apodeme
al jugalula (alula)
an anus
anp anterior notal process (suralare)
ant antenna
ap anterior piece
as antero-lateral series
axc axillary cord
b body of tentorium (corpotentorium)

ba	basisternum
be	basanal ossicle (basanale)
bg	basigalea
bp	basal piece (tegmen)
bs	basistipes
C	Costa
c	coxite
ca	cardo
cc	coxal cavity
ce	neck (cervix)
cf	pleural coxal process (coxifer)
cl	claw (unguis)
cm	connecting membrane
cn	condyle
cp	coxal process
cs	clypeal suture
Cu	Cubitus
cu–a	cubito-anal cross vein
cx	coxa
d	dorsal arm
dg	distigalea
di	digitus
e	compound eye
ed	endodorsum
ei	epipleuron
em	elytral margin of jugalula
ep	epipharynx
es	epicranial suture
f	ring-like sclerite
fe	femur
fp	fronto-postclypeus
fs	furcasternum
ft	furcal arm
fu	furcal pit
g	gula
ge	gena
gp	gular pit
gs	gular suture
gss	gulo-submental suture
h	cephalo-ventral arm (tergite 9)
i	axillary sclerite
in	subnotal suture
ip	lateral cervical plate (lateral cervicale)
is	interocular series
j	ejaculatory duct
k	dorsal plate of median lobe
ker	katepimeron
ket	katepisternum
ks	internal shelf
l	labrum
la	lacinia
lg	ligula
ll	lateral lobe
lm	anterior or lateral margin
lp	labial palpus
M	media
ma	molar area
m–cu	medio-cubital cross vein
md	mandible
me	metanotal groove (median)
mek	metasternal keel
mg	glossa
ml	median lobe
mn	mentum
mo	second axillary sclerite (median ossicle)
mp	maxillary palpus
ms	medistipes
msk	mesosternal keel
mts	metasternal spine
mu	muscle disc
n	precoxal fold or suture
nm	notal margin of jugalula
nt	1st axillary sclerite (notale)
oc	occiput
od	occipital condyle (odontoid process)
of	occipital foramen
p	pleurite

pa	parietal sclerite
pb	postalar bride (postalare)
pc	precoxal bridge (antecoxale)
pe	prepectus
pf	palpifer
pg	postgena
ph	prephragma
pi	posterior or sutural margin
pl	parocular sclerite
plg	palpiger
plm	pleural membrane
pls	parocular suture
pm	prementum
pn	pseudopleuron
pnp	posterior notal process (adanale)
po	posterior arm
pp	posterior piece
pph	postphragma
pr	paraglossa
prs	parascutellum
prt	prealar bridge (prealare)
ps	parastipes
psc	prescutum
psl	postscutellum
pt	pretarsal process
px	postcoxal bridge (postcoxale)
R	Radius
r	ventral rod
r–m	radio-medial cross vein
R_s	stem of radial sector
rt	remnant of first abdominal tergite
s	sternite
Sc	Subcosta
sc	scutum
sh	pronotal shelf
si	scutal incision
sl	scutellum
slm	scutellar margin
sm	submentum
sn	spiniferous margin
sp	spiracle
sr	scutellar ridge
ss	surstylus
st	stylus
su	pleural suture
sul	subalar plate (subalare)
t	tergite
ta	tarsus
te	tendon
tc	trochantral cavity
ti	tibia
tis	tibial spur
tn	trochantin
to	median orifice (gonopore)
tr	trochanter
v	vertex
vf	''valvifer''
vn	articulating notch of ''valvifer''
vp	ventral grooved plate
vr	eversion rod
w	wedge cell
wp	wing process
x	corrugated area
y	precervicale
z	postcervicale

Plate VII

Figure 1. Head, dorsal view.
Figure 2. Head, ventral view.
Figure 3. Left mandible, lateral view of proximal portion.
Figure 4. Left mandible, mesal view of proximal portion.
Figure 5. Right mandible, dorsal view of proximal portion.
Figure 6. Right mandible, ventral view.
Figure 7. Left mandible, ventral view.
Figure 8. Right antenna, ventral view.



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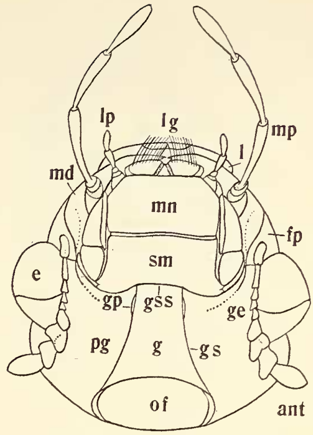

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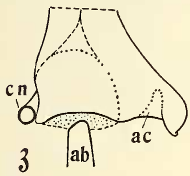

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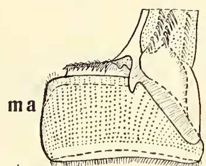

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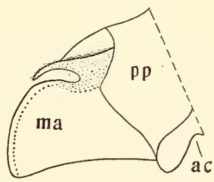

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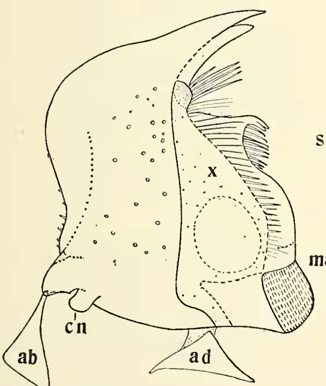

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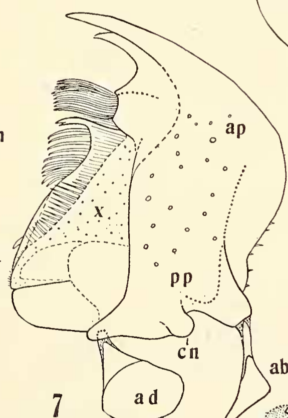

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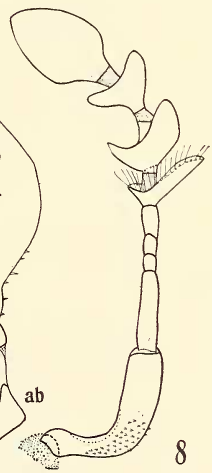

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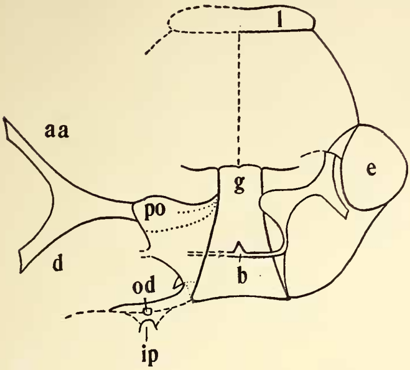
PLATE VIII

Figure 9. Endoskeleton of the head from above.
Figure 10. Labrum and epipharynx, ventral view.
Figure 11. Right maxilla, dorsal view of distal portion.
Figure 12. Right maxilla, ventral view.
Figure 13. Labium, ventral view.



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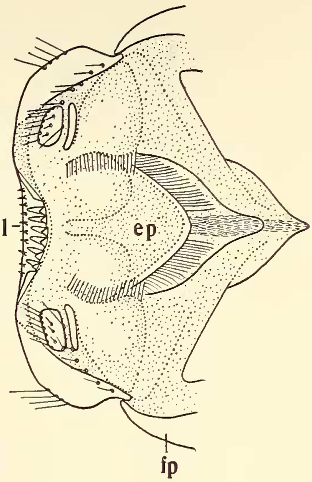

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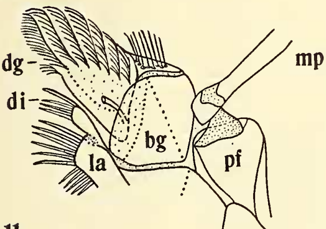

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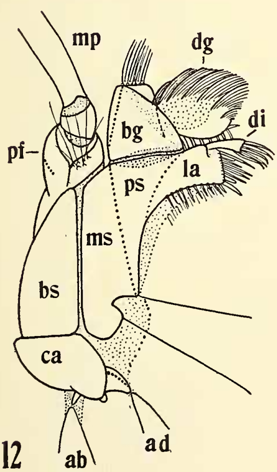

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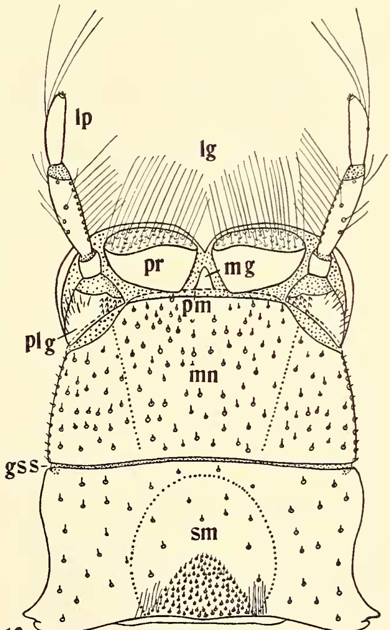

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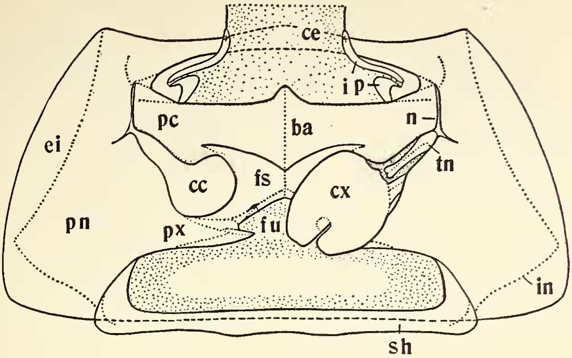
PLATE IX

Figure 14. Prothorax, ventral view.
Figure 15. Coxal process, ventro-mesal view.
Figure 16. Coxal process and trochantin, dorso-lateral view.
Figure 17. Right prothoracic trochanter, in situ, ventral view.
Figure 18. Right prothoracic leg, caudal view, female.
Figure 19. Right prothoracic claw, caudal view, male.
Figure 20. Lateral cervical plates, lateral view.



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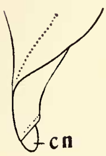

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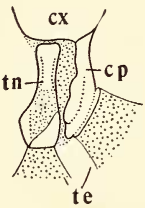

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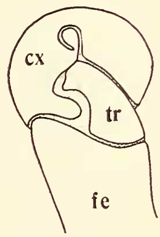

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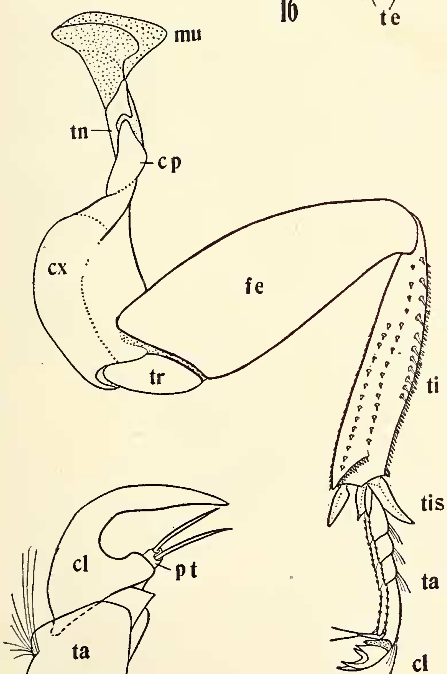

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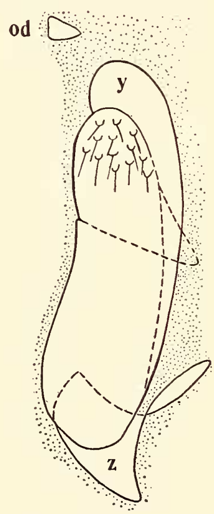

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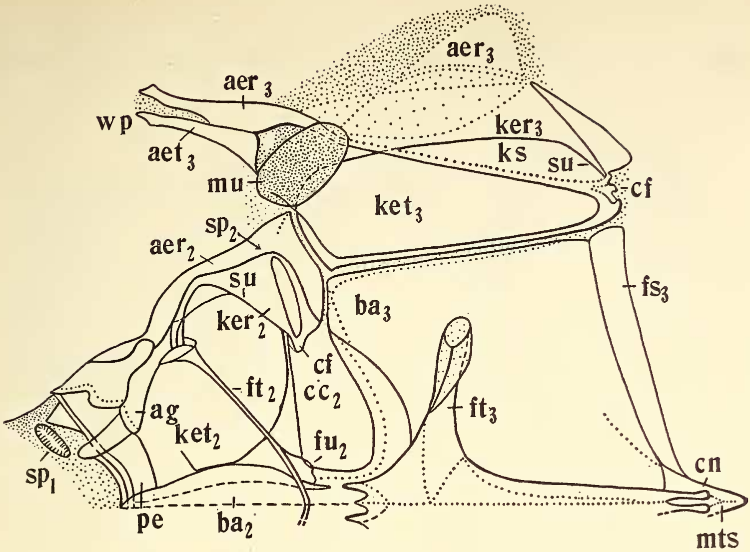
PLATE X

Figure 21. Internal view of sternum and pleuron of the meso- and meta-thorax, together with furcal processes. Right side only.

Figure 22. External view of same sclerites as shown in figure 21.



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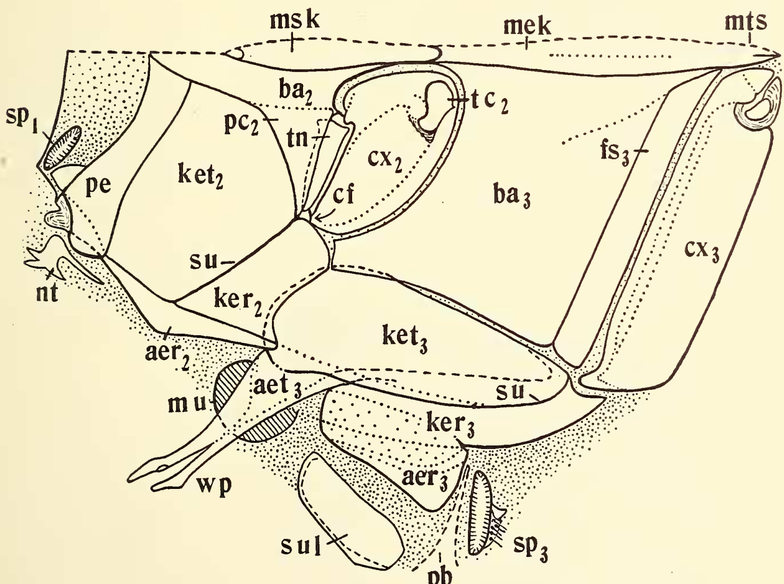

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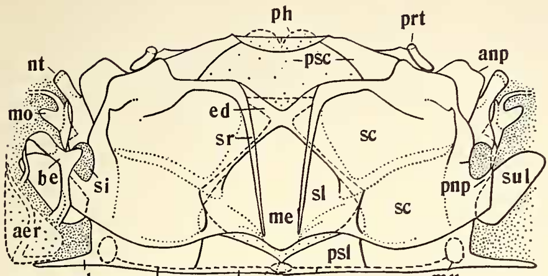
PLATE XI

Figure 23. Metathorax, dorsal view.
Figure 24. Left jugalula, dorsal view.
Figure 25. Mesothorax, dorsal view.
Figure 26. Left elytron, ventral view.
Figure 27. Left elytron, dorsal view.
Figure 28. Right wing, dorsal view.



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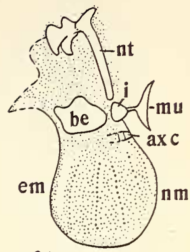

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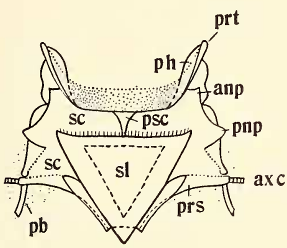

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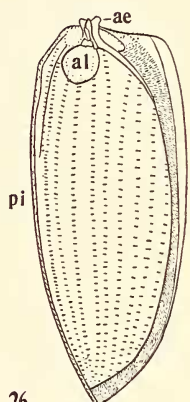

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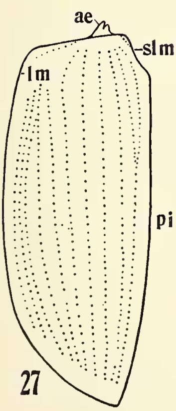

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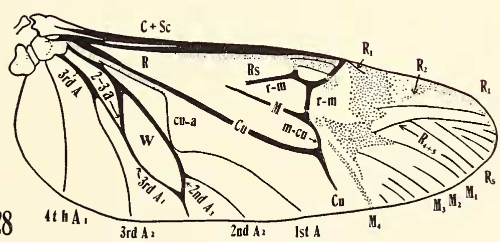

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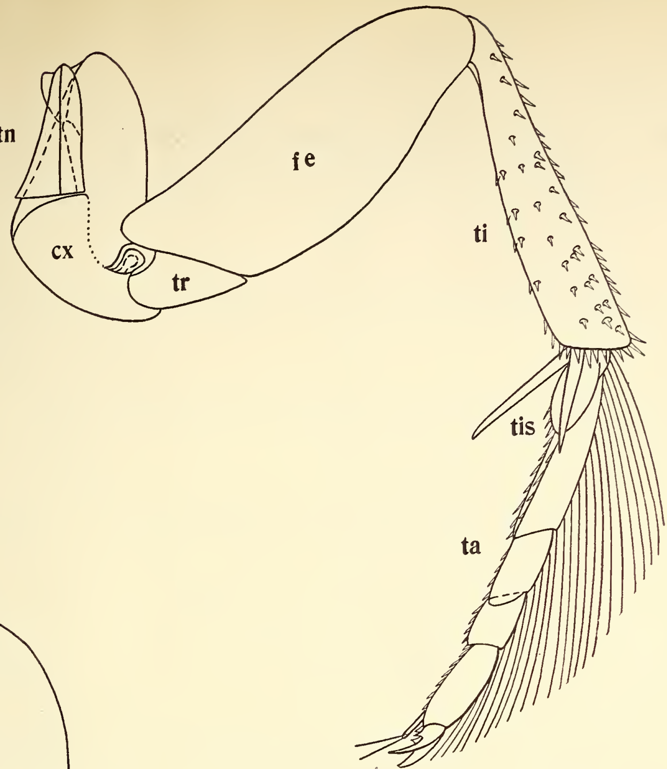
PLATE XII

Figure 29. Left mesothoracic leg, cephalic view, female.
Figure 30. Left metathoracic leg, cephalic view, female.



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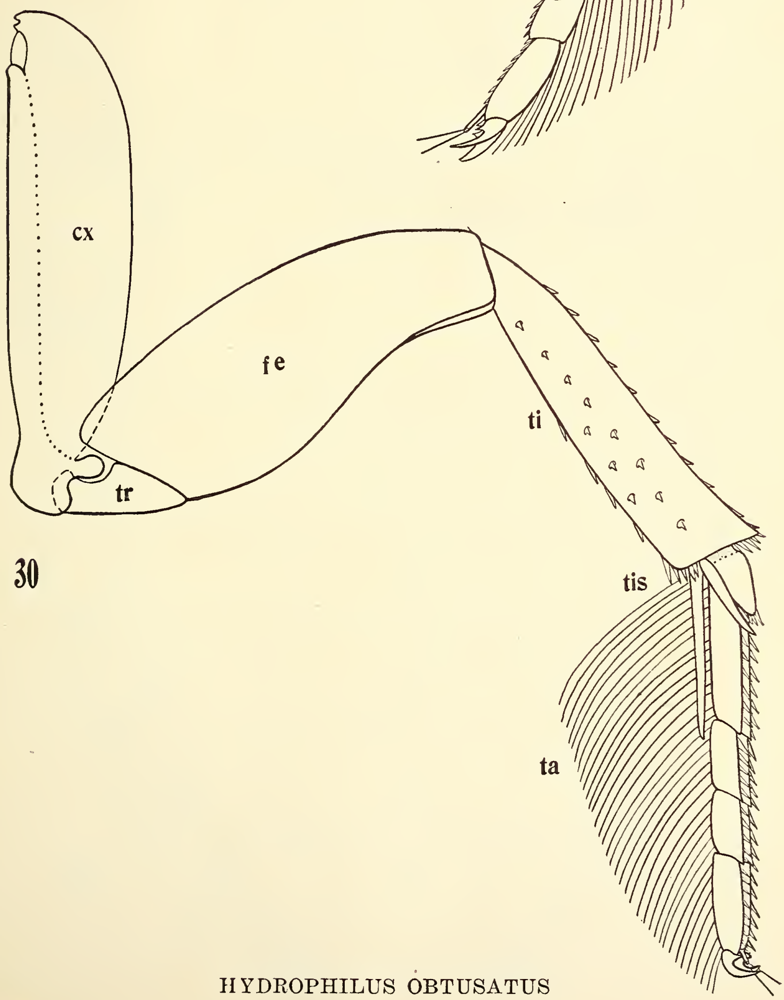

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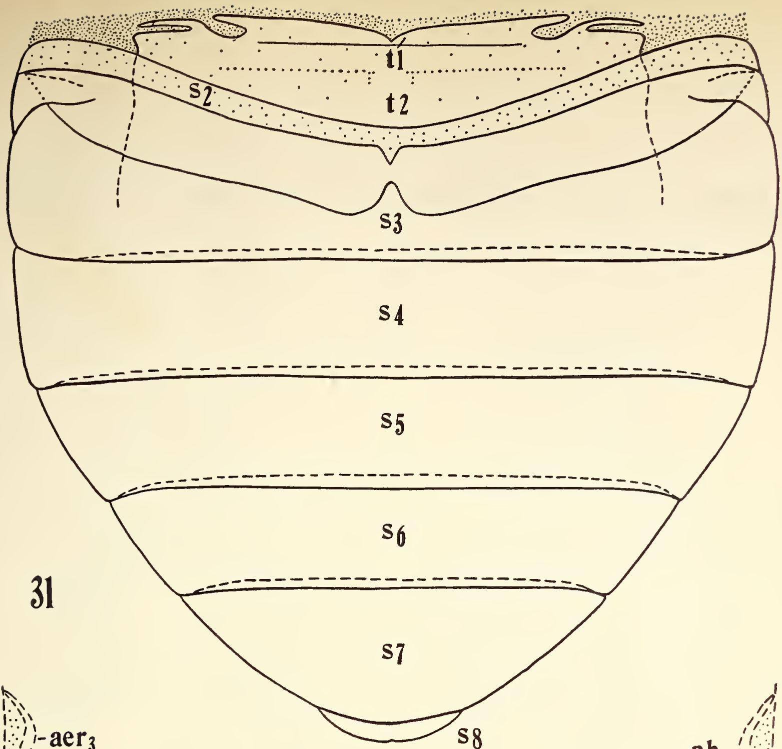
PLATE XIII

Figure 31. Abdomen, ventral view, female.
Figure 32. Abdomen, dorsal view, female.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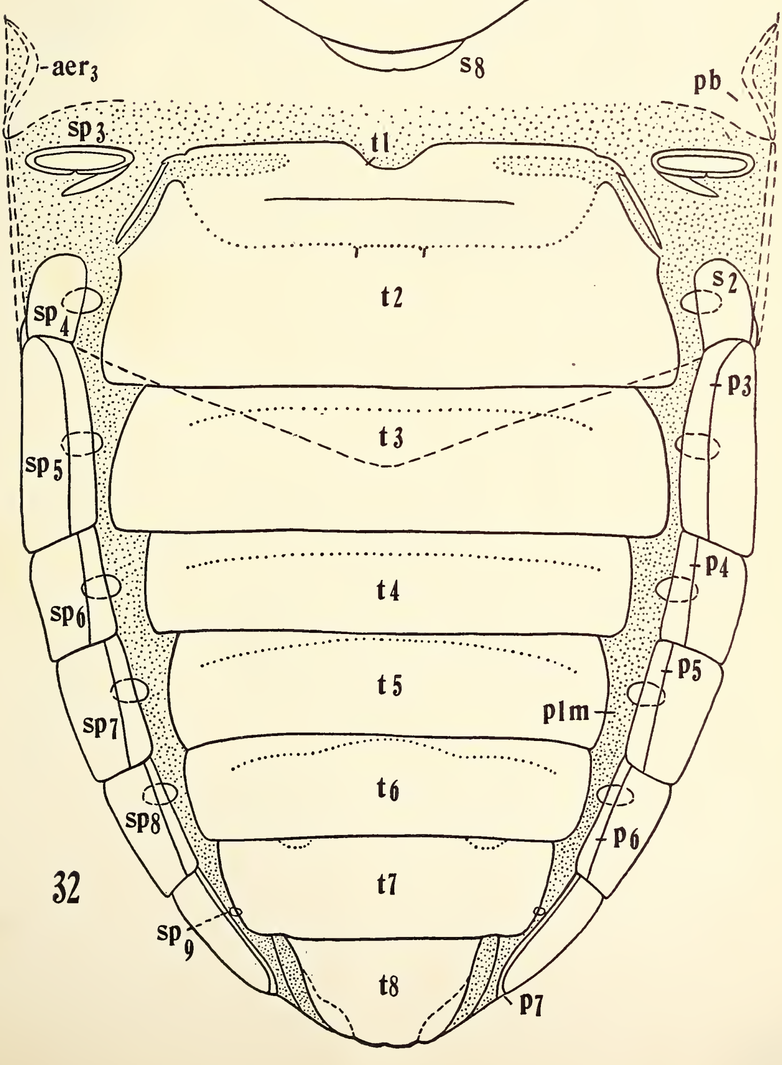
31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sp7
t6
sp8
p6
t7
sp9
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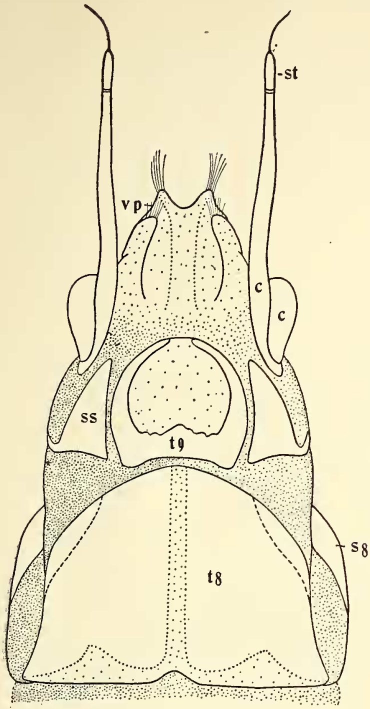
PALTE XIV

Figure 33. Terminal abdominal segment, dorsal view, female.
Figure 34. Terminal abdominal segment, ventral view, female.
Figure 35. Terminal abdominal segment, lateral view, female.



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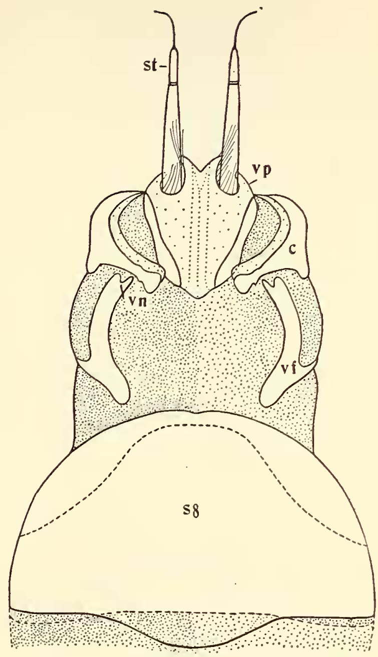

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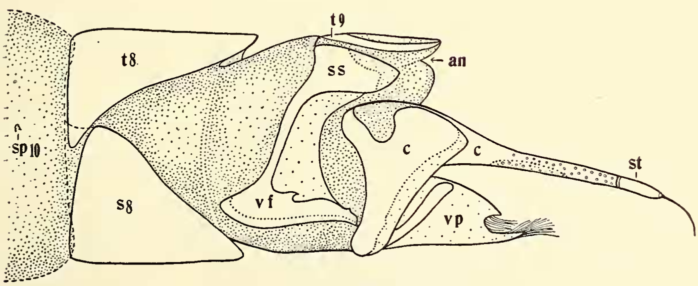

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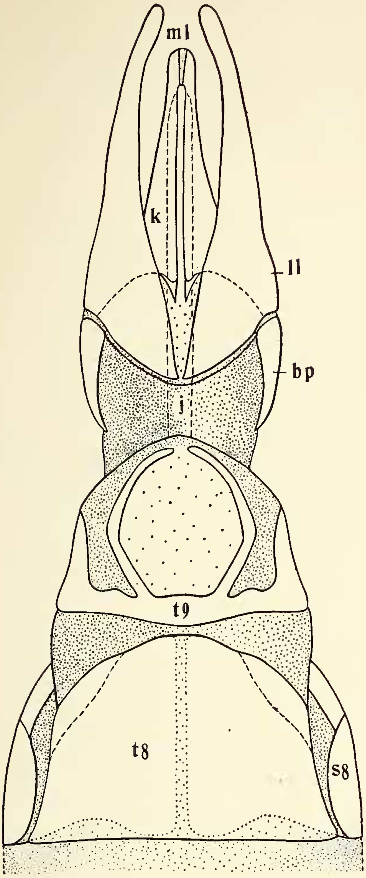
PLATE XV

Figure 36. Terminal abdominal segment, dorsal view, male.
Figure 37. Terminal abdominal segment, ventral view, male.
Figure 38. Ninth abdominal sternite and adjacent sclerites, ventral view, male.



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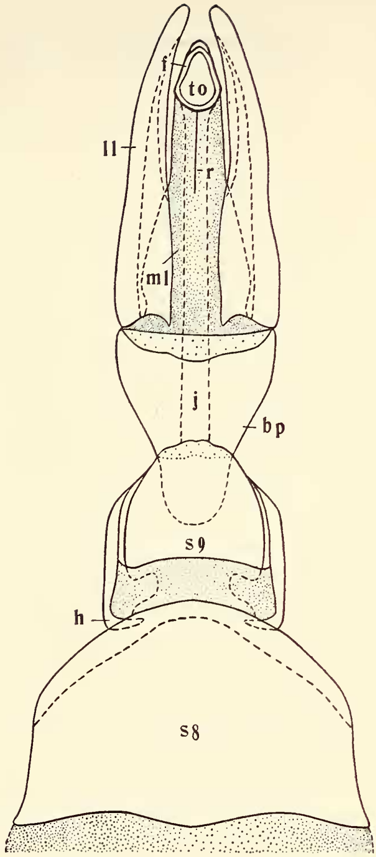

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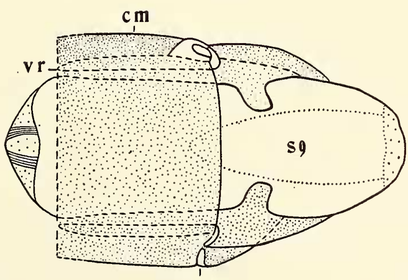

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